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# Time-of-use electricity pricing for industrial customers: A survey of U.S. utilities

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## HIGHLIGHTS

- We survey 43 TOU programs offered by U.S. utilities targeting industrial customers.
- We interpret key pricing components and characteristics of TOU tariff sheets.
- Switching from flat to TOU rates results in savings ranging from −72.0% to +82.6%.
- Implications for customers, utilities, and regulatory agencies are discussed.

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## ABSTRACT

Time-of-use (TOU) pricing serves as a cost-effective way to realize electricity demand response, which aims at relieving peak demand. Customer participation is critical to the success of TOU pricing programs. To fulfill the potential of such programs, customers must be able to access electricity tariffs and understand their terms. This paper reports a survey of 43 TOU pricing programs targeting industrial customers offered by U.S. utilities. This work is inspired by and complements the Federal Energy Regulatory Commission survey of demand response in the electric power industry, highlighting the interpretation of key pricing components and specific characteristics of TOU tariff sheets collected from public sources. The case studies examine various industrial scenarios to predict electricity cost savings when customers are facing the transition from flat rates to TOU pricing. The analysis results show that the cost savings vary enormously, ranging from −72.0% to +82.6%, depending on specific utility programs and switching strategies involved. Such information is useful for customers to determine whether to participate in a TOU pricing program. Key findings and implications for industrial customers, utilities, and regulatory agencies are also discussed.

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## 1. Introduction

It is commonly observed that 10% of peak demand in the U.S. electric systems occurs within 1% of the hours in a year [1]. An example of the hourly electric load on the PJM energy market in 2013 [2] is shown in Fig. 1. There are a total of 49 h with demand greater than 90%, which is only 0.56% of the hours in the year.

The peak demand usually occurs during the summer months, and it is satisfied through building costly extra generation, transmission, and distribution capacities, which are idled most of the time in the year. If the peak demand during the few hours can be alleviated, the power grid stability would be greatly improved without excessive supply-side investment, which translates into a multi-billion dollar saving annually. In fact, a 5% reduction of peak demand in the U.S. would eliminate the need for installing about 625 peak power plants and the associated delivery infrastructure [3].

Demand response is a mechanism that encourages customers to reduce load when the demand is highest [4–11]. It is a technology component of the bigger smart grid framework [12–14]. The National Institute of Standards and Technology (NIST) is currently in the early stages of developing standards for various smart grid components and interoperability [13]. However, demand response program planning and implementation are taking place in the U.S. despite the inadequacy of standards [12]. In demand response programs, customers reduce their loads in exchange for various financial benefits offered by utility companies. Demand response programs can take a number of different forms, depending on the program objectives, targeted customers, and design components.

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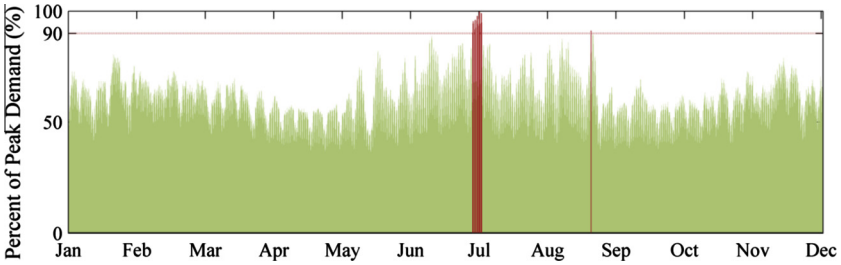


**Fig. 1.** Hourly electric load on the PJM energy market in 2013.

They can generally be divided into two categories: incentive-based programs and time-based programs [15].

An example of the incentive-based programs is interruptible load [16–18]. Interruptible load refers to the "electric consumption subject to curtailment or interruption under contracts that provide a rate discount or bill credit for agreeing to reduce load during system contingencies" [15]. The interruption requests are sent to customers on short notice, usually ranging from several hours to a few minutes in advance. A substantial penalty may be imposed for failure to interrupt.

An example of the time-based programs is time-of-use pricing [19–21]. It is "a rate where usage unit prices vary by time period, and where the time periods are typically longer than one hour within a 24-hour day" [15]. TOU pricing differs from another time-based program, real-time pricing [22,23], in which the electricity prices fluctuate hourly or more often.

This paper is concerned with TOU pricing. Among the three types of programs mentioned above, TOU pricing is the easiest implementation of demand response and requires least technological transformation. It is especially suitable for entry-level customers who have little knowledge of tariffs other than the traditional passive, flat rates with continuous electricity supply. This is because the more often the prices change, the more information the customers need to collect and the more often they need to respond. Given their previous experience and unfamiliarity with making frequent active consumption decisions, the customers may quickly lose interest in tracking the rates, usage, and accordingly reprograming electric equipment. This phenomenon is called "response fatigue" in the literature [24]. Therefore, the customers can take a step-by-step strategy: shift from the flat rate to a two- or three-tiered (on-peak, mid-peak, off-peak) TOU rate, and then proceed to more dynamic real-time pricing after they grow certain familiarity with such programs and consumption adjustments. Similarly, this will also avoid the frustration with significant intrusion on the schedule of industrial production or the comfort of building occupants due to premature adoption of the interruptible load program.

To fully realize the potential of demand response in the U.S., customers must be able to access the electricity tariffs and understand their terms. Customer education and pricing information transparency are critical to the success of demand response programs, as mentioned by the FERC's (Federal Energy Regulatory Commission) National Action Plan [25] and Implementation Proposal [26] on Demand Response. The National Action Plan and Implementation Proposal suggested establishing a web-based clearinghouse to serve as a centralized location for collecting all publicly available information on demand response, including regulatory documents, program tariffs, and other general information. As a supporting effort, NIST is taking actions to develop standards for the provision of energy price information [26]. Such information would be useful for customers to predict electricity consumption and benefits of various demand response strategies.

The importance of customer education and pricing information transparency is also evidenced by the deployment experiences of existing demand response programs. For example, Ipsos MORI [20] has conducted a nationwide survey in Great Britain to gain a better understanding of customer experiences with TOU pricing. Among all the surveyed TOU pricing users, overall 15% have been caused considerable upset, discomfort, or ill health attributed to the TOU tariff; 33% do not understand their metering and bills very well or not at all; 35% believe their tariff is not right for their households' needs; 38% are likely to be spending more on electricity than they need to, and over 50% believe additional information or advice would help them make better use of the tariff. The survey concludes that the information on the times when the electricity is cheaper is likely to be most helpful. A second example is related to a survey of U.S. utilities' experiences with real-time pricing conducted by the Lawrence Berkeley National Laboratory [27,28]. One of the major findings of the survey is that, while customers need help understanding and managing price risk, such assistance from the real-time pricing utilities is limited. Only one-third of the programs offer technical support for customers to identify strategies for price response. The Berkeley Lab survey implies in order to extend participation, sufficient resources should be devoted to developing a customer education program and making the pricing information more transparent.

Motivated by these facts, we plan to conduct a survey of TOU pricing programs offered by U.S. utilities. This paper documents the survey process and major findings. We start with analyzing the latest nationwide large-scale demand response survey conducted by the FERC, with a particular focus on TOU pricing programs. Then we proceed to conduct our own survey by collecting and interpreting the TOU tariffs of 43 largest utilities in the U.S. in terms of the numbers of customers enrolled in these TOU programs. These programs represent a wide range of TOU tariff designs. The detailed rate schedule information from each utility is identified and tabulated for future reference. Finally, such TOU tariffs are compared with the otherwise applicable traditional flat rates, so the customers can estimate the benefits of switching from the flat rate to the TOU rate and ultimately the dollar value of these benefits.

The main objectives of our survey efforts are to educate potential customers and expand customer participation in TOU pricing programs, to guide existing customers to get the best from their TOU tariffs, and to provide a reference of exemplary tariffs to utility companies that are interested in designing new TOU programs. It is also our hope that this research could be used to facilitate standard institutes to develop standards taking into account better pricing information, as well as to help regulatory policy makers assess the overall potential contribution of this specific demand response technology in peak demand reduction.

## 2. Brief literature review

It should be mentioned that related surveys on TOU pricing have been previously conducted by a few researchers and organizations. For example, Faruqui and Malxo [19] conducted a survey

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